CIR 1443

UNIVERSITY OF FLORIDA
IFAS EXTENSION

Strawberry Pest Management Strategic Plan (PMSP)[1]

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Executive Summary

Florida ranks second in the U.S. in the production of strawberry, providing 15 percent of the total U.S. crop, and 100 percent of the domestically-produced winter crop. In 1999-2000, 220,500,000 pounds of fresh berries valued in excess of $167 million were produced on 6,300 acres ($26,500/acre). There were 6,900 acres of production reported in 2002. Over the last 15 years, Florida strawberry growers have increased their acreage 40 percent and their production volume 70 percent, while income has increased 300 percent. Because of the great value of winter strawberries and the high competition on either end of the production window, this crop is highly integrated in all aspects, especially pest management. However, the future loss of methyl bromide is the

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largest IPM consideration for this production system. Secondary pests (such as thrips) and emerging pests (such as whitefly and aphids) do exist for Florida strawberry producers. Additionally, resistance issues (generally for miticides but also noted for a herbicide) exist in this production system. PMSP members expressed confidence that these issues may well be addressed by a combination of research, education, and regulatory actions.

Research

1. Continued examination of new chemistries that address gaps in pest management (resistance, efficacy, or selectivity).

2. Assessment of cover crops for nematode management.

3. Examination of current pest practices on vertebrate feeding deterrence.

Education

1. Education of growers/scouts with regard to pest identification and sanitation, especially on transplants.

2. Education of growers/pest managers with regard to new application methods and resistance management of new chemistries

Regulation

1. Continue processing ongoing requests for registration (methyl iodide, pyridaben, buprofezin, nicobifen, pyrimethanil, and sulfentrazone).

2. Determine if data exists that would allow PHI and plant-back interval modification for several management tools.

3. Interact with registrant/state agency to obtain state registration of clopyralid (Stinger®) in strawberry with existing data.

Introduction

Florida ranks second in the U.S. in the production of strawberry, providing 15 percent of the total U.S. crop, and 100 percent of the domestically-produced winter crop. In 1999-2000, 220,500,000 pounds of fresh berries valued in excess of $167 million were produced on 6,300 acres ($26,500/acre). There were 6,900 acres of production reported in 2002. Over the last 15 years, Florida strawberry growers have increased their acreage 40 percent and their production volume 70 percent, while income has increased 300 percent. Approximately 95 percent of Florida's commercial strawberry production acreage is located in Hillsborough and Manatee counties with the remainder in several other counties in both north and south Florida. For this reason, a Pest Management Strategic Plan (PMSP) meeting for the Florida strawberry industry was conducted at the Farm Bureau office in Hillsborough County (Valrico), Florida.

Because of the great value of the crop as well as the initial investment, it has historically been recommended that Florida strawberries be grown only on full-bed plastic mulch, and that a multi-purpose fumigant be applied to the bed as the plastic is laid over it. Therefore, strawberries are grown as an annual crop in Florida using the hill (raised bed) system, with two to four rows of plants per raised bed. Methyl bromide, in combination with chloropicrin, is currently applied approximately two weeks prior to planting transplants for the management of soilborne diseases, nematodes, insects, and weeds. A single application at an average rate of approximately 140 to 180 pounds of product per acre is injected into the soil during construction of the raised-beds. Row middles are not treated. The bed is then immediately covered with plastic mulch.

Several principal varieties are cultivated in Florida and these varieties can change yearly. To avoid re-introduction of mites, nematodes and other pathogens to the treated beds, growers are encouraged to use only the best quality transplants available. Transplants are set in late September through early November. Drip and overhead irrigation is used to help establish plants and protect them from frost. Following early vegetative growth, the cool nights

and short days of winter stimulate the plant to produce flowers which, after pollination, develop into fruits ready for harvest in four to six weeks. This results in three or four crops of fruit from each plant (based on a 30-day cycle). Flowers are present on plants in production areas continuously from shortly after planting until the end of harvest, but there are typically two peak flowering periods each season, one in November or December, and the other in mid to late January. The average harvest period runs from late November through early April. Fruit are harvested by hand every two or three days throughout the harvest season. Due to the frequency of harvest, preharvest intervals (PHIs) and restricted entry intervals (REIs) are important factors when growers select pesticides for use on strawberries. Pesticides are applied exclusively by ground application equipment. Florida's warm, humid climate is ideal for the development of many insect and mite, nematode, disease, and weed pests. Additionally, birds can sporadically become severe economic pests by consumption and damage of the strawberries. All of these pests were discussed at the Florida strawberry PMSP meeting.

Mites

Spider mites of the family Tetranychidae (especially two spotted spider mite) are always the main mite pests, and cyclamen mites (family Tarsonemidae) are a sporadic mite problem. Transplants that arrive in Florida have been growing in northern fields (generally Canada or North Carolina) for months and have been exposed to various pest pressures. These producers try their best to provide pest-free plants, but many newer chemistries registered for field use on strawberry are not available to nurseries. Florida growers are encouraged by extension specialists to monitor the transplants upon receipt for mites as well as aphids, immature whiteflies, and diseases. Once the condition of the transplants is understood, growers should decide to seek healthier transplants or prepare for pesticidal treatment after overhead watering/establishment ends.

The establishment period (approximately three weeks) when bareroot transplants are being irrigated overhead is the first period of pest management and Florida strawberry growers have very few chemical options because the irrigation water washes off the active ingredient. Consequently, any pest problems are often chemically unmanaged until the establishment period has ended. During this period, mites and lepidopteran larvae are the key arthropod pests. Lepidopteran larvae that were small upon arrival of the transplants are mature by the time establishment ends, and uncontrollable by B.t. sprays at that point. Consequently, mature larvae are often treated with methomyl, even though methomyl is not compatible with a predatory mite program. It is not hard to see that initial transplant pest pressures set the stage as to whether a grower can use a beneficial mite program, as well as the entire mite/insect management program for the growing season. However, registration of spinosad on strawberry in 2002 has provided growers with a product that is less toxic to predatory mites than methomyl at roughly the same cost per acre.

It was also noted by growers that weaker plants are infested by mites more quickly than stronger plants. The economic threshold for spider mites is presence of any life stage on five percent of the leaflets. In terms of chemical miticides, abamectin was being used (and possibly overused) just prior to the registration of bifenazate and hexythiazox. Some growers were reporting resistance to abamectin. These three active ingredients now make up the core of the spider mite chemical management system, although some growers not using predatory mites use bifenthrin and fenbutatin-oxide as miticides. Even though there appears to be many options for mite management, it should be noted that seasonal applications are limited to one for hexythiazox, two of bifenazate or fenbutatin-oxide, and four of abamectin.

Before the introduction of bifenazate and hexythiazox, when abamectin sensitivity was being questioned, Florida strawberry growers had an estimated 40 percent adoption of predatory mite programs. With the introduction of the new miticide chemistries, that rate has dropped to 30 percent, even though the two systems were roughly the same cost as reported by growers in attendance. Growers reported the desire to have "clean plants" rather than those with mites on them. Although predatory mite

populations can withstand a few applications of certain insecticides (malathion, diazinon) over the season, one of the biggest impediments to the predatory mite program is that the liquid formulation of captan (used exclusively because the WP formulation leaves white residue) is toxic to predatory mites. Since captan is the backbone of the prophylactic fungicide program, it is a certainty that predatory mites will be sprayed and may be reduced to non-efficacious levels by these sprays. Thiophanate-methyl was also reported by growers to be detrimental to predatory mites.

The growers also expressed regret that an extension publication (*Berry Times*) produced by UF/IFAS Hillsborough County Extension Office has recently been expanded to include vegetables, but also minimalized with respect to technical advice for strawberry growers. The growers did demonstrate interest in having this publication "reinflated" for strawberry growers to include more "forward-looking" advice.

For strawberry miticides, there are no carbamate, organophosphate, carcinogen, PHI, or REI concerns with the currently registered materials. Pyridaben is on the second quarter work plan for EPA's FY 2004. Acequinocyl, a miticide receiving reduced risk chemical classification status, is a candidate for registration during the second quarter of EPA's 2004 work plan. Etoxazole received a tolerance for strawberry in September, 2003.

Insects

The three lepidopteran larvae that were reported as pests in the crop profile (*Spodoptera frugiperda, S. eridania, Helicoverpa zea*) were confirmed by growers as the main "worm" problems, with "budworm" (*H. zea*) as the most damaging. These are mainly early season pests, and the ramifications of their presence during establishment have already been described. Mid- and late-season insect pests include thrips, aphids, and sap beetles. Sap beetles are a zero tolerance pest. Presence of larvae in a ripe strawberry can lead to rejection of the whole shipment.

For those growers employing predatory mites, B.t. and spinosad are the preferential materials for "worm" management so that predatory mite populations are conserved. For those using exclusive chemical control, methomyl, spinosad, and bifenthrin are often used. Growers expressed desire to transition away from methomyl, as the restricted status carries regulations with regards to licensing and recordkeeping. Similarly, there are other insecticides which may be phytotoxic due to strawberry variety, temperature, or incompatibility with other active ingredients. These active ingredients are: carbaryl, dicofol, naled, propargite, oils (petroleum and neem), soaps, and sulfur. Perhaps the best example of this is for petroleum oil and captan/sulfur. In this case, the user is cautioned not to use oil in combination with or immediately before or after spraying with captan or any product containing sulfur. Statements discouraging sulfur use within four weeks of an oil application are also common on oil products. Consequently, growers face these constraints when deciding an insect spray program.

As strawberries begin to form on the plants, chemical cues radiate to surrounding natural areas. These cues attract adult sap beetles of mainly two different genera that deposit their eggs preferentially in rotting strawberries, although a few may be deposited in fresh strawberries. The most important steps to take to manage sap beetle problems is to pick all fruit as soon as they mature and not leave behind any fermenting fruit. In addition to giving pickers incentive (money) to pull the rotting fruits, the fruit should also be taken out of the field. The second best practice is to drop them into the row middles, where they decay too quickly for the beetles to complete their life cycle. The pressure from sap beetles is most intense during the last month of production, when picking is most intense. The five active ingredients used to control sap beetle are bifenthrin, diazinon, pyrethrins, carbaryl, and malathion. But bifenthrin and pyrethrins can be hard on predatory mites, and there are potential phytotoxicity issues with carbaryl, so diazinon and malathion are used more than the others for sap beetle control. However, the PHI for diazinon is five days and the PHI for malathion is three days. Since the picking is done at two day intervals, growers expressed desire to have a PHI of two days for both diazinon and malathion.

During the last month of picking is also a time in Florida when oak and citrus blooms are concluding. Flower thrips move from these locations into the

strawberry fields. However, it has also been noted that the beneficial six-spotted thrips is present in substantial numbers in Florida if the insecticidal spray program is not too "hard." Consequently, an effort should be made to educate growers regarding the differences between these two thrips groups (beneficial or pest). When flower thrips do become problematic, spinosad or methomyl is used. The new tolerance for imidacloprid on strawberry may provide another tool for flower thrips control once it is registered in Florida.

Aphids (strawberry and melon) have recently become more persistent in localized areas than they have been historically. The presence of aphids and their cast skins and sugary excretions on fruit are objectionable to consumers and reduce quality of the fruit. Although there are several aphid predators in Florida, the most effective is a parasitic wasp. As with the six-spotted thrips, "hard" chemical programs can reduce the level of parasitism and allow aphid populations to increase. Growers wishing to reduce aphids before naturally occurring predators and parasites have done so must rely on insecticides. A number of materials are efficacious on aphids, such as diazinon, malathion, methomyl, naled, azadirachtin, *Beauveria bassiana*, bifenthrin, and endosulfan.

A potential emerging insect problem is whitefly (usually greenhouse whitefly). The biggest concern for Florida strawberry growers is that plant material from California will harbor the inoculum for major outbreaks in Florida similar to those now occurring in California. Consequently, Florida growers utilizing material from California should be educated on how to scout transplants for all whitefly life stages.

For strawberry insecticides, there are no carcinogen or REI concerns with the currently registered materials. As mentioned, growers expressed desire to have a 2-day PHI for malathion and diazinon. The malathion IRED is scheduled for FY 2003 and perhaps the PHI change can be addressed at that time. One concern in terms of IPM may be that there is only one efficacious compound (spinosad) for mature worms that will not drastically harm predatory mites. Pyridaben is on the third quarter work plan of EPA's FY 2003, methoxyfenozide and thiamethoxam are on the third quarter of EPA's 2004 work plan, and rotenone and pyrethrins still have to go through tolerance reassessment. Buprofezin (for whitefly management) is an A priority on IR-4's 2002 Food Use Workshop list.

Nematodes

This arena of Florida strawberry pest management is in the greatest turmoil due to the phaseout of methyl bromide. The methyl bromide replacement question is an entire multi-year program in itself, and the critical use exemption process has clouded the picture, as this program may or may not make limited quantities of methyl bromide available beyond the currently scheduled phase out date. At this point, growers have been resigned to pay dearly for methyl bromide as the quantity produced becomes less, or try the best alternative strategy currently available, which is viewed as an initial application of 1,3-dichloropropene and chloropicrin followed by a subsequent application of chloropicrin in combination with napropamide and oxyfluorfen as herbicide partners, applied directly to the bed top immediately prior to the plastic laying operation. The members of the PMSP meeting believed that approximately ten to 15 percent of growers would try using this alternative in 2003. This replacement is available because the registrant just recently provided the EPA with data that helped in reducing the PPE requirements for applying 1,3-dichloropropene. Additionally, the former 300-foot buffer zone has been reduced to 100 feet. Application advances have also helped make the use of 1,3-dichloropropene/chloropicrin a potential partial replacement for methyl bromide, exclusive of weed control. One remaining constraint of this system is that a minimum of 21 days must pass before planting versus ten to fourteen days with methyl bromide. Time is a critical component when profitability comes during a few weeks of harvest. Experimental work is continuing with other compounds such as iodomethane and metam sodium. Research with azadirachtin and *Myrothecium verrucaria* (Ditera®) have demonstrated these to be nonefficacious in field conditions.

In addition to the nematodes that are resident in Florida soils, there are also nematodes present on the transplant tissue received at the beginning of the

season. Regardless of source, the main pests are sting nematode and root-knot nematode. Work with nematode-suppressing cover crops such as sunn hemp have been initiated, but sting nematode seems to be quite mobile in the soils. Results have shown initial reductions, but sting nematode populations rise quickly when feeding opportunities (strawberry roots) are present.

For strawberry nematicides, there are no carbamate, organophosphate, carcinogen, or REI concerns with the currently registered materials with the exception of the methyl bromide phaseout. Iodomethane (methyl iodide) is on the second quarter work plan of EPA's FY 2003, and methyl bromide must go through tolerance reassessment.

Diseases

The key diseases reported by growers at the PMSP meeting were those listed in the crop profile, namely Botrytis (gray mold) and Colletotrichum diseases (anthracnose, fruit rot, and crown rot). Other problematic and emerging diseases include angular leaf spot, powdery mildew, and Phytophthora diseases.

Botrytis attacks strawberry fruit in all stages of development in the field and in transportation. Years in which conditions are cool and wet during the major bloom period (mid-January to mid-February) provide exceptional disease pressures on Florida strawberries. Thankfully, several new chemistries have been introduced to help manage this fungus and growers reported utilizing all of them (cyprodinil + fludioxonil, fenhexamid). However, the backbone of the prophylactic fungus control program is the rotation and use of captan and thiram. This is illustrated by the 2002 NASS survey data, which reported a conservative average of 9.5 applications of captan and 4.1 applications of thiram.

One of the characteristics of the newer materials for disease control are extensive label limitations. All of the new compounds mentioned above (as well as azoxystrobin and pyraclostrobin) have four application limits per season. Azoxystrobin, pyraclostrobin, and fenhexamid are not to be used more than twice in a row without switching to an alternative mode of action. The registrant for azoxystrobin and cyprodinil + fludioxonil (Switch®) has also obtained labeling for each of these as a dip for the transplants, so one of the foliar applications in the field will now probably be lost to a dip application. There is also a 12-month restriction on plant back for the mixture of cyprodinil and fludioxonil. Growers made it apparent that this plant back limitation restricts the use of this material, as many of them would like to cultivate a quick-growing crop such as a cucurbit after the strawberry picking has terminated. So it is apparent that growers have a limited number of applications of the new and much costlier fungicides. They view these as supplements to the backbone spray program.

There are three species of Colletotrichum fungus that affect Florida strawberry production, *Colletotrichum fragariae, C. gloeosporioides, and C. acutatum*. Fruit and root rot are generally caused by *C. acutatum*. Crown rot can be caused by the other two species. In fact, crown rot was the disease that led to the demise of the strawberry nursery industry in Florida. The strobilurin fungicides have shown to be most effective in managing anthracnose fruit rot prophylactically. However, there was consensus among meeting members that growers were uncertain as to the number of applications that could be made since limitiations are either prescribed on a season, crop, or yearly basis. Having a new dip label may also confuse growers as to the number of field applications that can be made.

Angular leaf spot is caused by the bacterium *Xanthomonas fragariae*. Transplants often arrive infected from the nursery. Cold, wet conditions (including overhead sprinkling for establishment or freeze protection) encourage disease outbreaks. Copper fungicides and hydrogen peroxide applications help to suppress this pathogen.

Powdery mildew is a sporadic/emerging fungal problem. The disease is typically managed with fall applications of myclobutanil or thiophanate-methyl. However, thiophanate-methyl cannot be used by those growers using predatory mites, and resistance to myclobutanil is suspected by members of the PMSP meeting. Consequently, some growers are going back to sulfur for management, and others are having good

success with potassium bicarbonate. Triflumizole has also been newly registered for management of powdery mildew in strawberry.

Two Phytophthora species (*P. cactorum and P. citricola*) occasionally cause crown rot and leather rot in Florida strawberries. Subsequent to the methyl bromide application, mefenoxam is applied early to control this fungus and fosetyl-Al and potassium phosphite are used later in the season because those two materials can be sprayed on the foliage.

Other strawberry diseases are intermittent or incidentally controlled by applications intended to control target diseases. For strawberry fungicides, there are no additional IPM, PHI, or REI concerns with the currently registered materials. There has recently been a meeting held in Cincinnati, Ohio by TERA for captan to determine if its carcinogenic potential can be reclassified based on new EPA guidelines. Thiram and thiophanate-methyl are currently undergoing reregistration and the Agency has intimated that it would like to mitigate some of the perceived risk of thiram. Pyrimethanil is on the third quarter work plans of EPA's FY 2004, and dodine still has to go through tolerance reassessment. However, Florida strawberry growers did not report using dodine in 2002. Boscalid received a tolerance for strawberry as of July, 2003.

Weeds

Weed pressure has historically been one of the more difficult management aspects for Florida strawberry growers for several reasons. First, when methyl bromide is employed as the sterilant, the dormant weed seeds such as Carolina geranium and cut-leaf evening primrose are not inactivated. Since no treatment is capable of controlling weed emergence the entire strawberry season (six to seven months), these weeds become mid- to late-season problems that impact quality and harvest efficacy. The desired effect of methyl bromide is that it does control the majority of yellow and purple nutsedge, which are considered the worst weeds in this crop. Since the methyl bromide alternatives (except for methyl iodide) don't control nutsedge, these species as well as the aforementioned late season weeds will be a problem in rows during some or most of the season.

Another consideration with respect to weeds is their ability to harbor spider mites. Soon after transplants are set, Carolina geranium seedlings appear. The potential for mite reinfestation is not great when the weed grows from transplant holes in the plastic mulch, because in that position miticide applications will kill resident mites on both the weeds and strawberry plants. However, this plant also grows in the row ends and field perimeter, and these areas are not treated. Consequently, spider mites can reinfest fields from these plants after miticide residues have decreased.

Herbicide research for strawberry has also lagged behind that of pepper and tomato due to the economic superiority of these two crops and the fact that some herbicides available to tomato and pepper growers are not and will not be available to strawberry growers. The most recent report from the USDA's methyl bromide alternatives program (Spring 2003) reviewed only soil sterilants and one herbicide (Devrinol®) and did not address weed speciation. Results from solarization treatments were similar to those of the untreated control. Consequently, Florida strawberry growers have little experience with new herbicide alternatives.

Herbicide resistance has also been observed in Florida strawberry production. Goosegrass in the row middles has become resistant to paraquat, due to heavy reliance on this single herbicide. Growers also reported potential glyphosate damage to strawberry plants due to transmission from shallow roots present in treated row middles. In addition to nutsedge and resistant weeds, other problematic weeds include purslane, pusley, Carloina geramium, cut-leaf evening primrose, and eclipta. Dayflower is an emerging weed problem.

Weed pressure in Florida strawberry production comes from two locations, in-bed and the row middles. There are several herbicides which currently provide a degree of control in most cases for row middles. As noted, weeds in the bedded portion of the field, historically managed by methyl bromide application, are now considered the weakest point of methyl bromide alternatives. The following points list the issues with each of the in-bed herbicide options:

Napropamide (Devrinol®) appears to have reasonable early season efficacy for most weed species. Degradation leads to loss of weed control mid- to late-season with certain species more tolerant than others.

Oxyfluorfen (Goal® 2XL) appears to manage troublesome weeds such as Carolina geranium and cut-leaf evening primrose, but the use is through fallow bed labeling, which requires a 30-day post application fallow. This length of time is too long between bed formation and transplanting, as mentioned in the nematode section.

Terbacil (Sinbar®) appears promising but there is a label restriction (110-day PHI) that make this product almost useless for the Florida strawberry growing system. Extension specialists are trying to work with the registrant to refine this label with respect to the extended PHI.

The remaining herbicides available for Florida growers are non-selective or grass-killing postemergence herbicides. One last consideration regarding herbicides (and especially Roundup® products) is the addition of different active ingredients to established trade names. There is a new formulation of Roundup® that offers 24-hour weed control. This is accomplished by the addition of diquat to the glyphosate. Growers must be mindful that this type of addition has become more commonplace, and that they must examine the label to make sure the products they need do not also contain an active ingredient not allowed on strawberry. Other than the aforementioned, there are no IPM or REI concerns with the currently registered materials. Carfentrazone-ethyl, a relatively new non-selective herbicide, is on the third quarter work plan of EPA's FY2004. Sulfentrazone is an A priority on IR-4's 2002 Food Use Workshop list and clopyralid is labeled nationally for strawberry, but is not registered in the State of Florida.

Birds

Bird predation of strawberries is a sporadic event, but in years in which it occurs, losses can be substantial. The species primarily associated with this phenomenon are American robin, cedar waxwing, and crows. This past season was a good example of bird predation, wherein it is estimated that robins consumed approximately 400,000 flats of strawberries (over $2 million in losses). An extension specialist that works with vertebrate pests stated that the current technologies (propane cannon at a rate of one per ten acres or robin distress calls) have minimal efficacy, while twisted relective ribbon (silver on one side/red on the other) may be slightly more efficacious. Additionally, audio devices are generally not acceptable since much of the growing area is now bordered by residential developments. Since the strawberry is a "naked" fruit, taste repellents such as methyl anthranilate (grape flavoring) and capsaicin (pepper) cannot be used. The specialist stressed that the most important aspect in trying to rid ones field of birds is to try and scare them as soon as they start inhabiting the field. Flock presence draws in more birds.

One interesting potential for taste aversion that may well fit nicely into the current pest management program is the application of thiram when a flock first starts to land in the field. This fungicide is known to discourage other vertebrate pests from feeding, but none of the growers were aware of this fact.

Summary

Based on the input of the members of the Florida strawberry PMSP, the following items have been placed on the "To Do" list.

Research

1. Examine efficacy of milbemectin, pyridaben, and etoxazole on pest mites (and thrips for milbemectin) and toxicity to beneficial mites (and beneficial thrips for milbemectin) as well as phytotoxicity on current and potential Florida strawberry cultivars.

2. Examine an alternative mature caterpillar material such as methoxyfenozide.

3. Conduct trials to identify cover crops that will reduce nematode populations.

4. Conduct herbicide screening trials with flumioxazin, sulfentrazone, and carfentrazone.

5. Examine the use of thiram as a bird feeding deterrant.

Education

1. Rededicate effort on providing forward looking pest management issues in *Berry Times*, the newsletter cited by the growers as one of their historic information sources.

2. Educate growers/scouts with regard to whitefly identification and sanitation, especially on transplants.

3. Educate growers/pest managers with regard to dip applications and resistance management both for strobilurins (azoxystrobin, pyraclostrobin) and neonicotinoids (imidacloprid).

4. Educate growers to the issue that in some cases (e.g. Roundup®) a brand name associated with an active ingredient (such as glyphosate) may have something "new" in it (such as diquat) which will influence the overall performance of the application and may/may not be used on strawberry.

Regulation

1. Include candidate caterpillar management active ingredients in the regulatory queue.

2. Determine if residue data exists that would allow a 2-day PHI for malathion and diazinon.

3. Refine planting window (currently 21 days) for dichloropropene, if possible.

4. Eliminate or greatly reduce the 12-month plant back restrictrions for Switch®.

5. Greatly reduce the 110-day PHI for Sinbar®.

6. Interact with registrant/state agency to obtain state registration of clopyralid (Stinger®) in strawberry with existing data.

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- Aaron Grimes
- Carl Grooms
- Cammy Hinton
- Andrew McDonald
- Johnny St. Martin
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Registrant Personnel

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Table 1. Efficacy ratings for pest management tools against invertebrate pests in Florida strawberry.

Pests / Pest Management Tools	TSM	Other Mites	FT	SB	Aphids	FAW	SAW	CEW	TB	SMC	LCB	SLR	OLT	TPB	Whiteflies	Frujt flies	Mole Crickets	Ants	Slugs
Registered materials																			
Abamectin	G	G	F		F										F				
Azadirachtin	F		F	F	F	F	F	F	F	G		F	F		G	F			
Bacillus thuringiensis						G	G	G	G	G		G	G						
Beauveria bassiana	P		P	P	P	P	P	P	P	P		P	P		P			P	
Bifenazate	E																		
Bifenthrin	P		F	G	P	F	F	F	F			G						P	
Canola oil	...																		
Carbaryl																	P	F	
Chlorpyrifos	...																		
Cinnamaldehyde	...																		
Diazinon	P	G	F	G	G														
Dicofol	P	G																	
Disulfoton	P				F														
Endosulfan		G	F		F	F		F	F						F				
Fenbutatin-oxide	G																		
Fenpropathrin	P		F	G	F	F	F	F	F	G		G			F				

Abbreviations:
TSM = two-spotted spider mite
FT = flower thrips
SB = sap beetles
FAW = fall armyworm
SAW = southern armyworm
CEW = corn earworm

Abbreviations:
TB = tobacco budworm
SMC = saltmarsh caterpillar
LCB = lesser cornstalk borer
SLR = strawberry leafroller
OLT = omnivorous leaftier
TPB = tarnished plant bug

Rating scale:
E = excellent;
G = good;
F = fair;
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Hexythiazox	E																		
Malathion	P		F	G	F	F	F	F				F			P	G			
Metaldehyde																			
Methomyl			F		G	G	G	G	G			G	G						
Methoxychlor	...																		
Naled	P		F		F														
Neem oil	...																		
Paraffinic oil	...																		
Insecticidal soap	...																		
Propargite	...																		
Pyrethrins + rotenone	P		F									G							
Pyrethrins + piperonyl butoxide			F	F	F	P	P	P	P	G		G	G		P	E	P	P	
Spinosad			G			G	G	G				E	E						
Sulfur																			

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New Chemistries - IR4 (■ current IR-4 project)																			
■ Acequinocly/TM 413	E																		
■ Etoxazole	E																		
■ Fenpyroximate	E																		
■ Imidacloprid			P		E										E				
Methyxofenozide																			
■ Milbemectin	G	?	?		G										F				
■ Pyridaben	E	G													E				
■ Pyriproxyfen	E				F										E				
■ Thiamethoxam					G										E				

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Cultural/Non-chemical																			
Certified pest-free plants	EF	EG			F														
Crop rotation											F						F	F	
Removing ripe fruit from field				G															
Resistant varieties	EF																		
Sanitation	G	G		G											G	G			G
Traps																			
Weed control	G																		G
Biological controls																			
Beneficial mites	E	P	P																
Damsel bugs					P	P	P	P	P	P			P	P					
Big-eyed bugs	P				P														
Ground beetles						P	P	P	P	P			P	P					
Lacewings	P				P	P	P	P	P	P			P	P					
Ladybird beetles	F				F														

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Minute pirate bugs	P	P	F			P	P	P	P	P		P	P		P				
Parasitic wasps				?	G	F	F	F	F	F		F	F		G				
Predatory midges	P				P														
Predatory thrips	F	?																	
Spiders	P		P			P	P	P	P	P		P	P						
Syrphid fly larvae	P				F														

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Table 2. Toxicity of pest management tools to beneficials in Florida strawberry.

Beneficial Insects/ Mites / Pest Management Tools	Beneficial mites	Big-eyed bugs	Damsel bugs	Ground beetles	Honeybees	Lacewings	Ladybird beetles	Minute pirate	Parasitic wasps	Predatory midges	Predatory thrips	Spiders	Syrphid fly larvae
Registered materials													
Abamectin	MH					MH	MH		MH				
Azadirachtin	S					S	S		S				
Bacillus thuringiensis	S					S	S		S				
Beauveria bassiana	S					S	S		S				
Bifenazate	S					S	S		S				
Bifenthrin	H					H	H		H	H			
Canola oil	S					S	S		S				
Carbaryl	S					H	H		H				
Chlorpyrifos	H					H	H		H				
Cinnamaldehyde	?					?	?		?				
Diazinon	M					H	?		H	H			
Dicofol	H					SM	?		M	H			
Disulfoton	H					H	H		H				
Endosulfan	H					H	H		M				
Fenbutatin-oxide	S					S	S		S				

Toxicity scale:
S = slightly toxic
M = moderately toxic
H = highly toxic

Toxicity scale:
O = nontoxic
? = no data available

Table 2. Toxicity of pest management tools to beneficials in Florida strawberry.

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Fenpropathrin	H					H	H		H				
Hexythiazox	S					S	S		S				
Malathion	M					H	H		H				
Metaldehyde													
Methomyl	H					H	H		H				
Methoxychlor													
Naled	H					H	?		?				
Neem oil													
Paraffinic oil	M					S	S		S				
Insecticidal soap	H					H	?		M				
Propargite	MH					S	?		S				
Pyrethrins + rotenone													
Pyrethrins + piperonyl butoxide	MH					SM	?		MH				
Spinosad	MH					MH	?		MH				
Sulfur	SM					S	S		S				

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New Chemistries - IR4 (■ current IR-4 project)													
■ Acequinocly/TM 413													
■ Etoxazole													
■ Fenpyroximate	H					S	?		H				
■ Imidacloprid	MH					M	?		H				
Methyxofenozide													
■ Milbemectin	MH					MH	MH		MH				
■ Pyridaben	M					S	?		?				
■ Pyriproxyfen	S					S	H		S				
■ Thiamethoxam	?					?	?		?				

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Table 3. Indications for disease management products used on Florida strawberries

Management Product \ Disease	Angular leaf spot	Anthracnose[a] crown rot	Anthracnose[a] fruit rot	Anthracnose[a] root rot[b]	Botrytis fruit rot	Phytophthora diseases	Powdery mildew	Misc. leaf spots
Azoxystrobin			X	X	S		X	
Captan		X	X		X			X
Copper compounds	X							X
Cyprodinil + fludioxonil				X	X			
Fenhexamid					X			
Fosetyl-aluminum						X		
Hydrogen peroxide	X			X	X		X	X
Iprodione					X			
Mefenoxam						X		
Myclobutanil							X	X
Potassium bicarbonate			X		X		X	X
Potassium phosphite						X		
Pyraclostrobin			X		S		X	X
Pyraclostrobin + boscalid			X		X		X	X
Sulfur							X	
Thiophanate methyl		X			X		X	X
Thiram					X			
Triflumizole							X	

[a]Anthracnose diseases are caused by *Colletotrichum* species: *C. fragariae* and *C. gloeosporioides* (crown rot), *C. acutatum* (fruit rot, root rot)
[b]Anthracnose root rot is suppressed by dipping bare root runner plants in solutions or suspensions of the indicated products just before planting
X = labeled or used for control of indicated disease
S = for suppression only of indicated disease